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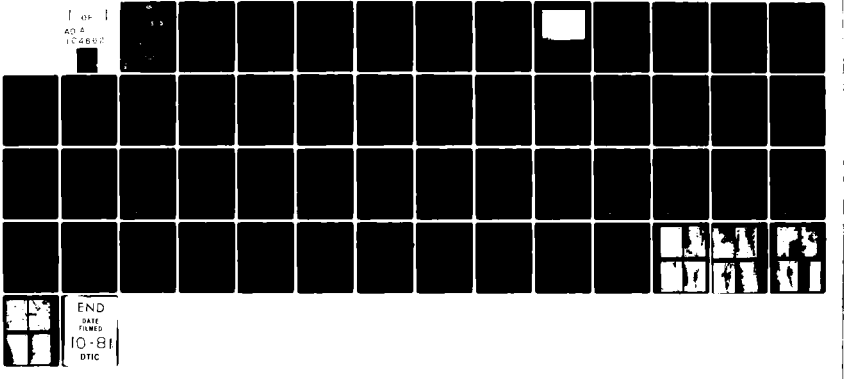

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MERRILL LAKE DAM

OZARK COUNTY, MISSOURI

MO 30352

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

AUGUST, 1980

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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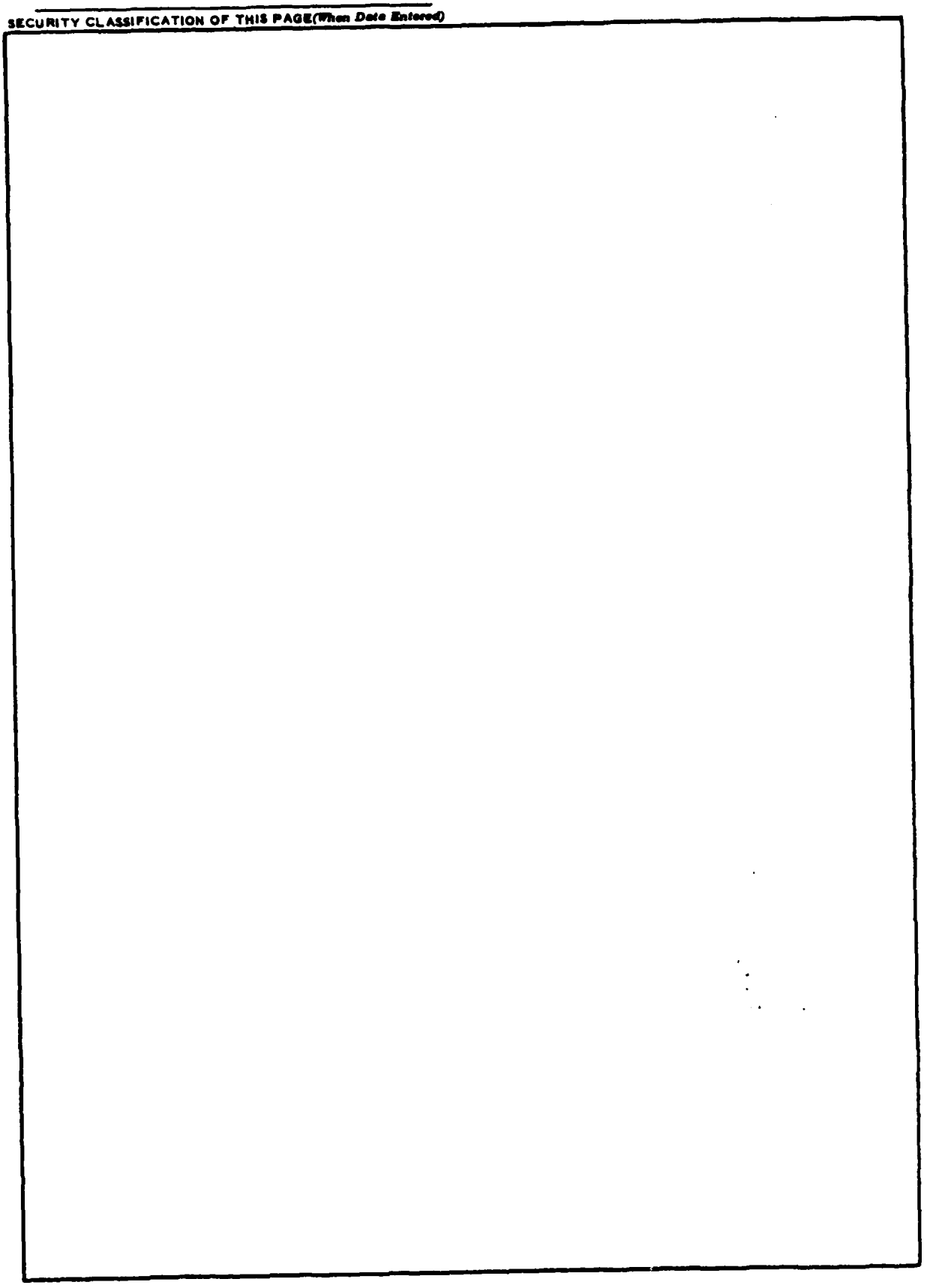

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Merrill Lake Dam, MO 30352, Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Merrill Lake Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

The spillway of this dam is borderline to pass 50 percent of the Probable Maximum Flood. The owner is encouraged to increase the spillway capacity as recommended in the report. This should be initiated immediately.

SUBMITTED BY: SIGNED
Chief, Engineering Division — 17 FEB 1981 — Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 17 FEB 1981 — Date

WHITE RIVER BASIN

MERRILL LAKE DAM
OZARK COUNTY, MISSOURI
MISSOURI INVENTORY NO. 30352

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

August, 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Merrill Lake Dam
State Located: Missouri
County Located: Ozark
Stream: Tributary of Lick Creek
Date of Inspection: June 19, 1980

Merrill Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately three miles downstream of the dam. Located within this zone are three dwellings, three buildings, and U. S. Highway 160 (fill barrier).

The dam is in the small size classification, since it is greater than 25 ft high but less than 40 ft high, and the maximum storage capacity is greater than 50 ac-ft but less than 1,000 ac-ft.

Our inspection and evaluation indicates that the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass 45 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering

the height of dam (26 feet), the maximum storage capacity (52 acre-feet) and the presence of the highway fill barrier downstream 50 percent of the PMF has been determined to be the appropriate spillway design flood. The 100-year flood (1 percent probability flood) will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being equaled or exceeded in any given year.

The embankment was in fair condition. Deficiencies visually observed by the inspection team were: (1) small trees on upstream face of embankment; (2) dense brush and trees on downstream face of embankment; (3) debris and trees in spillway channel; (4) animal burrows on embankment; (5) erosion in spillway outlet channel; (6) erosion at embankment - west abutment contact; (7) seepage at embankment-abutments contact; (8) wave erosion and sloughing of upstream face; and (9) probable excessive steep embankment slopes.

Another deficiency was the lack of seepage and stability analysis records.

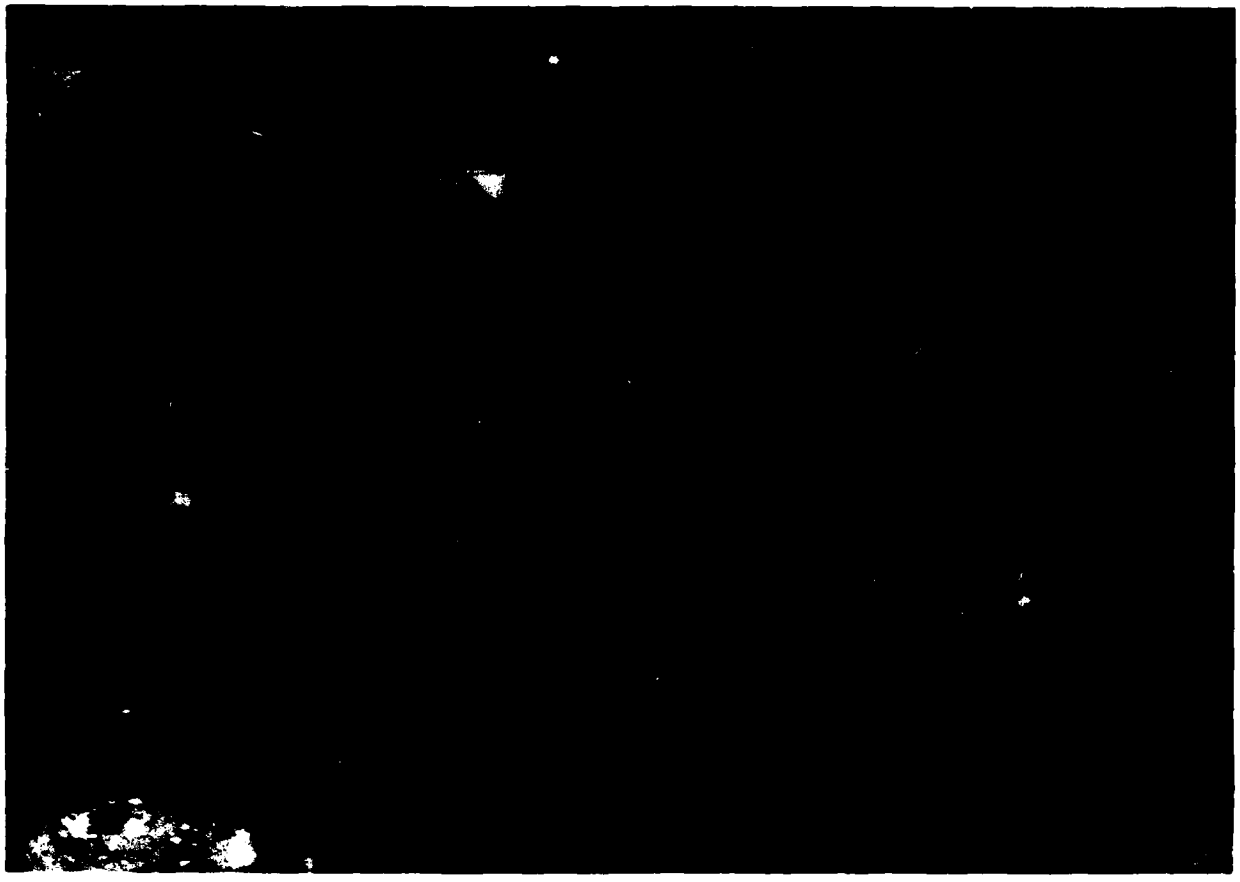
It is recommended that the owners take the necessary action without undue delay to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

Steve Brady, P.E.
Anderson Engineering, Inc.

Dave Daniels, P.E.
Hanson Engineers, Inc.

Nelson Morales, P.E.
Hanson Engineers, Inc.

Tom Beckley, P.E.
Anderson Engineering, Inc.



AERIAL VIEW OF LAKE AND DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
MERRILL LAKE DAM
MISSOURI INVENTRY NO. 30352

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APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Merrill Lake Dam in Ozark County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Merrill Lake Dam is an earth fill structure approximately 26 ft high and 250 ft long at the crest. The appurtenant work consists of rock cut swale in the west abutment.

Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankments.

B. Location:

The dam is located in the south central part of Ozark County, Missouri on a tributary of Lick Creek. The dam and lake are within the Gainesville, Missouri 7.5 minute quadrangle sheet (Section 04, T22N, R13W - latitude 36°36.4'; longitude 92°24.1'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 20 ft and a maximum storage capacity of approximately 52 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately three miles downstream of the dam. Located within this zone are three dwellings, three buildings and U. S. Highway 160 (fill barrier). The affected features located within the damage zone were verified during the site inspection.

E. Ownership:

The dam is owned by Mr. Robert Lewis Merrill. The owner's address is Box 145, Gainesville, Missouri (telephone number 417/679-4435).

F. Purpose of Dam:

The dam was constructed primarily for recreation.

G. Design and Construction History:

No design data or plans are available. Mr. Merrill built the dam in 1967. He acted in the capacity of the contractor with Mr. Lloyd Hamilton as the equipment operator.

Mr. Merrill stated that a core trench was cut to bedrock. The trench was approximately 15 feet wide and varied in depth to a maximum of 10 feet. Prior to placement of the clay core, 1,000 pounds of rock salt and a bran mix (cottonseed hulls) were spread over the bottom of the trench. According to Mr. Merrill, the bran mix would temporarily seal any small leaks that might develop. After the bran mix decomposed the salt would have crystallized forming an impervious core.

As the downstream slope was being finished to final elevations, a number of large trees were cut, trimmed and placed along the slope to provide for erosion control of the slope. A thin concrete slab was poured at the crest of the spillway section.

After the lake had filled, Mr. Merrill observed some seepage on the downstream embankment near the west abutment. He then placed an additional bran and salt mixture along the upstream face of the embankment. He stated that this procedure stopped the seepage.

H. Normal Operating Procedures:

All flows will be passed by the uncontrolled rock cut spillway in the west abutment. The owner stated that the dam has not been overtopped.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile, and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 33 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through an uncontrolled spillway.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 983.6): 210 cfs

(3) Estimated Capacity of Principal Spillway: 210 cfs

(4) Estimated Experience Maximum Flood at Dam Site: Unknown

(5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(7) Gated Spillway Capacity at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level elevation of 934.07 for north headwall of 48 inch diameter pipe under U. S. Highway 160 (elevation obtained from Missouri State Highway and Transportation Department).

(1) Top of Dam: 983.6 feet, MSL (Low point)

(2) Principal Spillway Crest: 981.4 feet, MSL

(3) Emergency Spillway Crest: Not Applicable

(4) Principal Outlet Pipe Invert: Not Applicable

(5) Streambed at Centerline of Dam: 958.5 feet, MSL

(6) Pool on Date of Inspection: 981.0 feet, MSL

(7) Apparent High Water Mark: Unknown

(8) Maximum Tailwater: Unknown

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 825 feet

(2) At Emergency Spillway Crest: Not Applicable

(3) At Principal Spillway Crest: 800 feet

E. Storage Capacities:

(1) At Top of Dam: 52 acre-feet

(2) At Emergency Spillway Crest: Not Applicable

(3) At Principal Spillway Crest: 42 acre-feet

F. Reservoir Surface Areas:

(1) At Top of Dam: 4.4 acres

(2) At Emergency Spillway Crest: Not Applicable

(3) At Principal Spillway Crest: 3.7 acres

G. Dam:

(1) Type: Rolled Earth

(2) Length at Crest: 250 feet

(3) Height: 26 feet

(4) Top Width: 9 feet

(5) Side Slopes: Upstream 1V on 1.9H, Downstream varies from 1V on 1.7H to 1V on 2.7H

(6) Zoning: Apparently Homogeneous

(7) Impervious Core. None

(8) Cutoff: Key trench to bedrock

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

(1) Location: West Abutment

(2) Type: Rock Cut Swale

(3) Upstream Channel: Rock Cut Channel

(4) Downstream Channel: Barely discernible earth channel, brush and tree covered with gentle slopes.

I.2 Emergency Spillway:

(1) Location: Not Applicable

(2) Type: Not Applicable

J. Regulating Outlets:

There are no regulating outlets associated with this dam.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No engineering data exist for this dam. No documentation of construction inspection records was available. There are no documented maintenance data.

A. Surveys:

No information regarding pre-construction surveys were obtained. Sheet 3 of Appendix A presents a plan, profile, and cross section of the dam from survey data obtained during the site inspection. The north headwall of a 48 inch concrete pipe under the embankment of U. S. Highway 160, approximately 800 feet southwest of the dam, was used as a site datum of elevation 934.02. The elevation of the concrete pipe was obtained from the Missouri State Highway and Transportation Department.

B. Geology and Subsurface Materials:

The site is located in the Ozarks geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus, and deep valleys. The most common bedrock types are dolomite, sandstone and chert. The Missouri Geological Survey indicates that the bedrock in the site area consists primarily of the Cotter-Jefferson City formation of the Canadian Series in the Ordovician System. The Cotter-Jefferson City formation is primarily a thin bedded dolomite with some chert and sandstone beds. The dolomite is extensively weathered in some areas with resistant rock outcropping in adjoining areas. The thin bedded dolomite is also relatively impermeable except that weathered portion near the surface.

The publication "Caves of Missouri" indicates eleven caves are known to exist in Ozark County. All of the caves reported are several miles from the site.

The "Geologic Map of Missouri" indicates a normal fault about three miles south of the site. The fault runs in a northeast-southwest direction. The Missouri Geological Survey has indicated that the faults in this area are generally considered to be inactive.

The soils overlying the Cotter-Jefferson City formation are of the Clarksville-Fullertonstone-Talbot Soil Association. The soils have developed from the dolomite bedrock and include clays, silty clays, sandy clays, all with chert fragments. The soil samples obtained from shallow auger probes in the embankment indicate the embankment is composed of brown to reddish-brown clayey-silts which fall within the Unified Soil Classification of CL-ML.

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analyses apparently were not performed as required in the guidelines. The owner indicated that the embankment fill was obtained from the lake area. He stated that a core trench approximately 15 feet wide and up to 8 feet deep was cut to bedrock.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for this dam were available. Based on field measurements of spillway dimensions and embankment elevations, and the watershed area, lake area and storage data from U.S.G.S. quad sheets, hydrologic analyses using U. S. Army Corps of Engineers guidelines were performed and appear in Appendix C, Sheets 1 to 9.

E. Structure:

There are no structures associated with this dam.

2.2. CONSTRUCTION:

No construction inspection data have been obtained.

2.3 OPERATION:

Normal flows would be passed by the uncontrolled rock cut spillway located in the west abutment. No operating facilities exist.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTON

3.1 FINDINGS:

A. General:

The field inspection was made on June 19, 1980. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steve Brady - Anderson Engineering, Inc. (Civil Engineer)
Dave Daniels - Hanson Engineers, Inc. (Geotechnical Engineer)
Nelson Morales - Hanson Engineers, Inc. (Hydraulic Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The embankment appears to be in fair condition. The upstream face of the embankment had some scattered small trees at the waterline.

The horizontal alignment of the dam was good, with a slight curve concave to the downstream slope. The embankment slopes from the east abutment to the spillway channel at the west abutment. A minor slough (15 feet long) was observed in the upstream slope near Station 1 + 00. No additional sloughing was observed. Erosion of the upstream slope at the waterline was observed all along the length of this dam, apparently due to wave erosion. No riprap protection for the upstream slope was observed. Some animal burrows were noted along the dam on the upstream slope.

No cracks were observed in the crest of the dam. The crest of the dam had generally good grass cover.

The downstream slope of the embankment was relatively steep (1V on 1.5H maximum) with a dense cover of trees and brush. A large amount of debris was noted on the downstream slope. Grass cover on the downstream slope was minimal. Some large rocks were noted along the downstream slope. No serious erosion or sloughs were observed along the downstream slope. The large tree trunks, placed on the slope by the owner, used for erosion control, prohibited a thorough inspection of the embankment.

Seepage, with no measurable flow, was observed at the west abutment-embankment contact commencing at about normal pool level and extending to the valley floor. An additional damp area was noted at the east abutment-embankment contact.

Auger probes in the crest of the dam indicated a brown, cherty, clayey silt (ML-CL).

C. Appurtenant Structures:

C.1 Principal Spillway:

The principal spillway is a rock cut swale located at the west abutment. The east slope of the spillway channel is formed by the dam embankment. A concrete slab has been placed over the east slope to protect the embankment from erosion. The west slope of the channel had been excavated to apparent bedrock. This rock appeared to be a cherty dolomite.

Trees are growing at the entrances of the approach channel and at the outlet channel. Mounds of rock, concrete, and other debris have been placed at the entrances of the approach channel and at the downstream embankment-spillway contact. This mound appeared to have been placed to divert flow away from the downstream embankment-spillway contact. Erosion channels 6 to 12 inches deep were observed at the downstream embankment-abutment contact. This erosion appeared to have resulted from flow through the spillway channel.

C.2 Emergency Spillway:

There is no emergency spillway associated with this dam.

D. Reservoir:

The watershed is primarily grassy pastureland with scattered large trees. The slopes to the reservior are moderate. No significant erosion or slouging was noted. The shoreline of the reservoir was tree lined. A green film due to the vegetation growth was observed on the lake. Siltation does not appear to be a problem with this dam.

E. Downstream Channel:

The downstream channel was barely defineable immediately downstream of the dam. Approximately 75 feet beyond the embankment toe, the channel was lined with heavy brush and tree growth. Within the brush and tree area, a marshy area was noted.

3.2 EVALUATION:

Trees and brush on the dam constitute a potential seepage hazard and encourage animal burrowing. There is no wave protection provided for the upstream face of the embankment and erosion will continue to deteriorate the embankment. The discharge of the spillway channel is reduced due to the trees, brush, and debris at the inlet and outlet sections and will restrict flood flows. Progressive erosion of the embankment-west abutment due to spillway releases would result in a decrease of the stability of the embankment.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

There are no operating facilities associated with this dam. The pool level is normally controlled by rainfall, runoff, evaporation, the capacity of the uncontrolled spillway, and apparent seepage from the reservoir.

4.2 MAINTENANCE OF DAM:

The presence of tree and brush growth, and the erosion of the upstream face indicates that little maintenance is done.

4.3 MAINTENANCE OF OPERATING FACILITIES:

There are no operating facilities associated with this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION.

The tree and brush growth on the dam, animal holes, erosion due to wave action and spillway discharges and seepage are deficiencies which should be corrected. Remedial measures should be investigated by an engineer experienced in the design and construction of dams. Subsequently, the areas should be inspected periodically to detect any further erosion or seepage.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic design computations for this dam were available.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed. The owner indicated that the dam has never been overtopped. Our hydrologic and hydraulic analyses using U. S. Army Corps of Engineers guidelines appear in Appendix C.

C. Visual Observations:

The approach channel to the spillway has numerous trees and brush. The outlet channel is fairly densely overgrown with trees. Additionally, rocks and debris have been placed at the inlet and outlet of the spillway channel to assist in diverting the discharge away from the embankment-abutment contact. Progressive flows could erode and weaken the embankment.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U. S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the reservoir storage and the pool and drainage areas from the Gainesville, Missouri 7.5 Minute U.S.G.S. quad sheet.

Based on the hydrologic and hydraulic analysis presented in Appendix C, the spillways will pass 45 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the height of dam (26 feet), the maximum storage capacity (52 acre-feet) and the presence of the downstream highway fill barrier (U.S. Highway 160) 50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillways will pass the 1 percent probability flood without overtopping the dam.

Application of the probable maximum precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 1,058 cfs. For 50 percent of the PMF, the peak inflow was 529 cfs.

The routing of the PMF through the spillway and dam indicates that the dam will be overtopped by 1.1 ft at elevation 984.7. The duration of the overtopping will be 0.7 hours, and the maximum outflow will be 788 cfs. The maximum discharge capacity of the spillway is 210 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 0.1 feet at elevation 983.7. The maximum outflow will be 245 cfs, and the duration of overtopping will be 0.25 hours. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

No design and construction data for the foundation and embankment were available.

Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

There have been no reported post-construction changes or modifications to this dam.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in fair condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) tree and brush growth on upstream and downstream slopes of the embankment; (2) animal burrows on upstream slope; (3) debris and trees in inlet and outlet of the spillway channel; (4) erosion on upstream face of embankment and at abutment contacts; (5) seepage at abutment contacts; and (6) possible excessively steep embankment slopes.

Another deficiency was the lack of seepage and stability analyses records.

The dam will be overtopped by flows in excess of 45 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will continue to deteriorate and possibly could become serious in the future. The items recommended in paragraph 7.2A should be pursued without undue delay.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no additional inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

(1) Spillway size and/or height of dam should be increased to pass 50 percent of the PMF. In either case, the spillway should be protected to prevent erosion.

B. O & M Procedures:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.

(2) Brush and tree growth should be removed from the embankment and the spillway channel. This should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam.

(3) The seepage areas at the abutment contacts should be investigated by a professional engineer experienced in the design and construction of dams. Remedial measures may be required.

(4) The animal burrows should be filled.

(5) The debris should be removed from the embankment and spillway channel.

(6) The erosional areas at the abutment contacts should be repaired and maintained.

(7) The outlet of the spillway channel should be diverted away from the embankment.

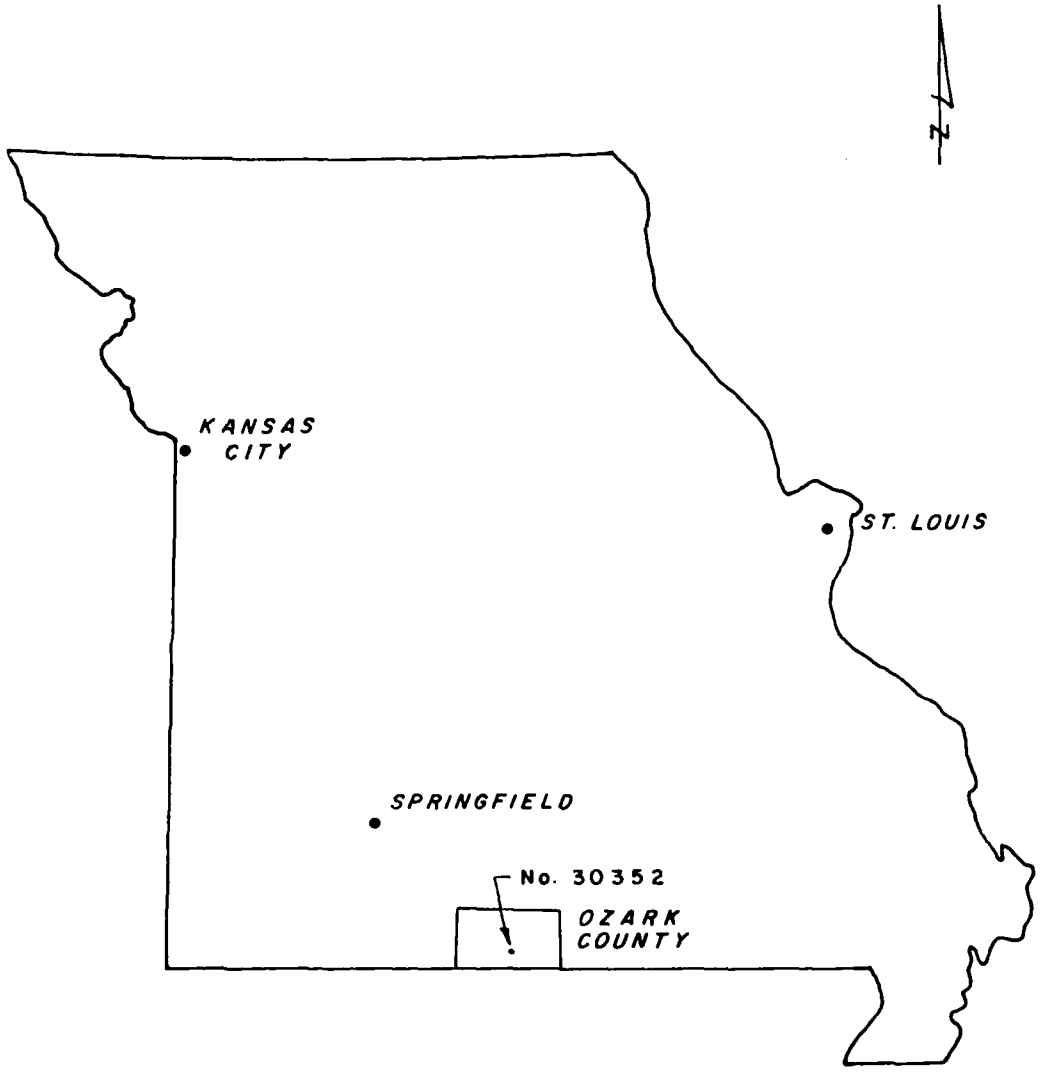
(8) Erosion of the upstream slope should be repaired and wave protection provided for the face.

(9) Analysis of the embankment slopes for adequacy should be accomplished by an engineer experienced in the design and construction of dams.

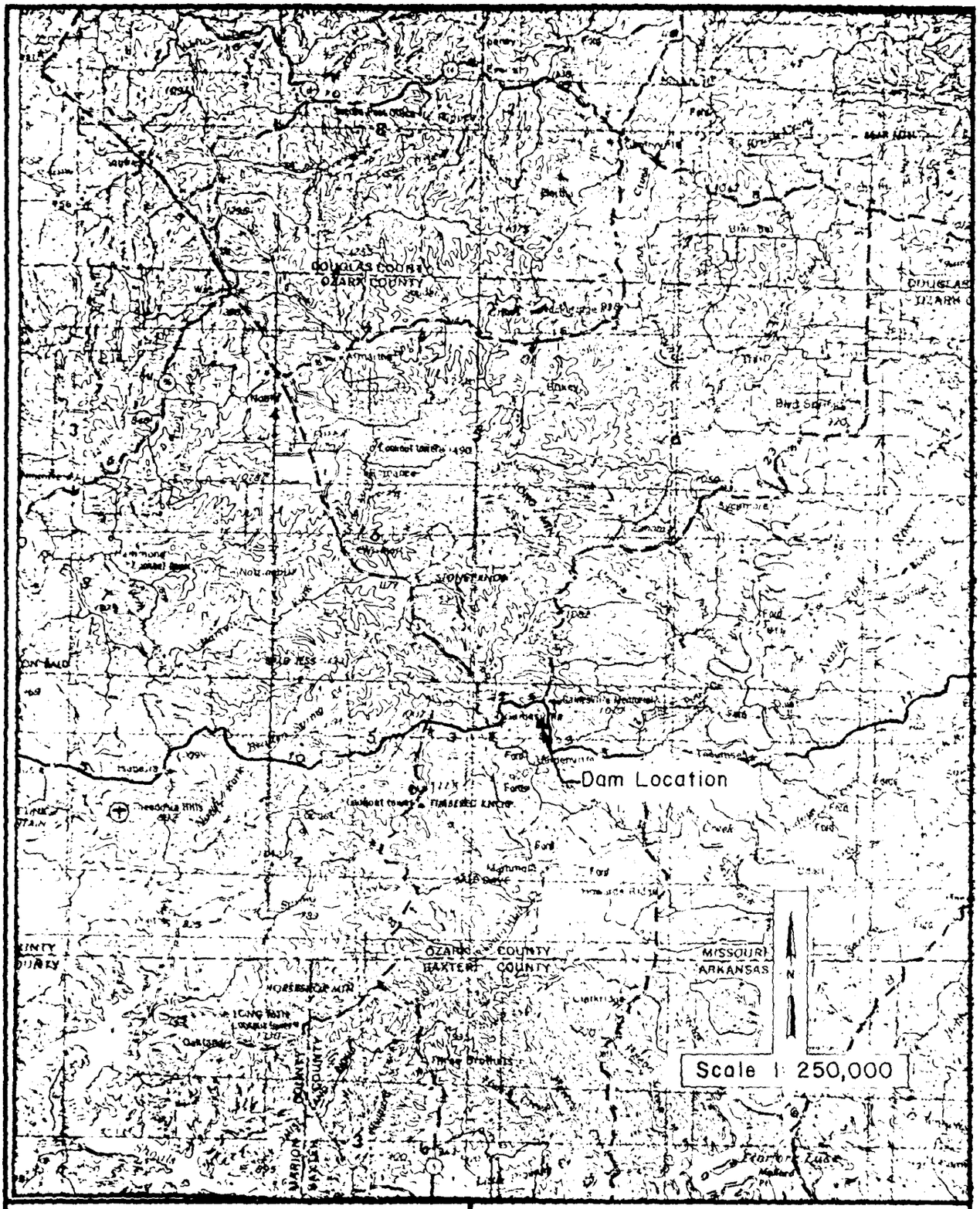
(10) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



LOCATION MAP



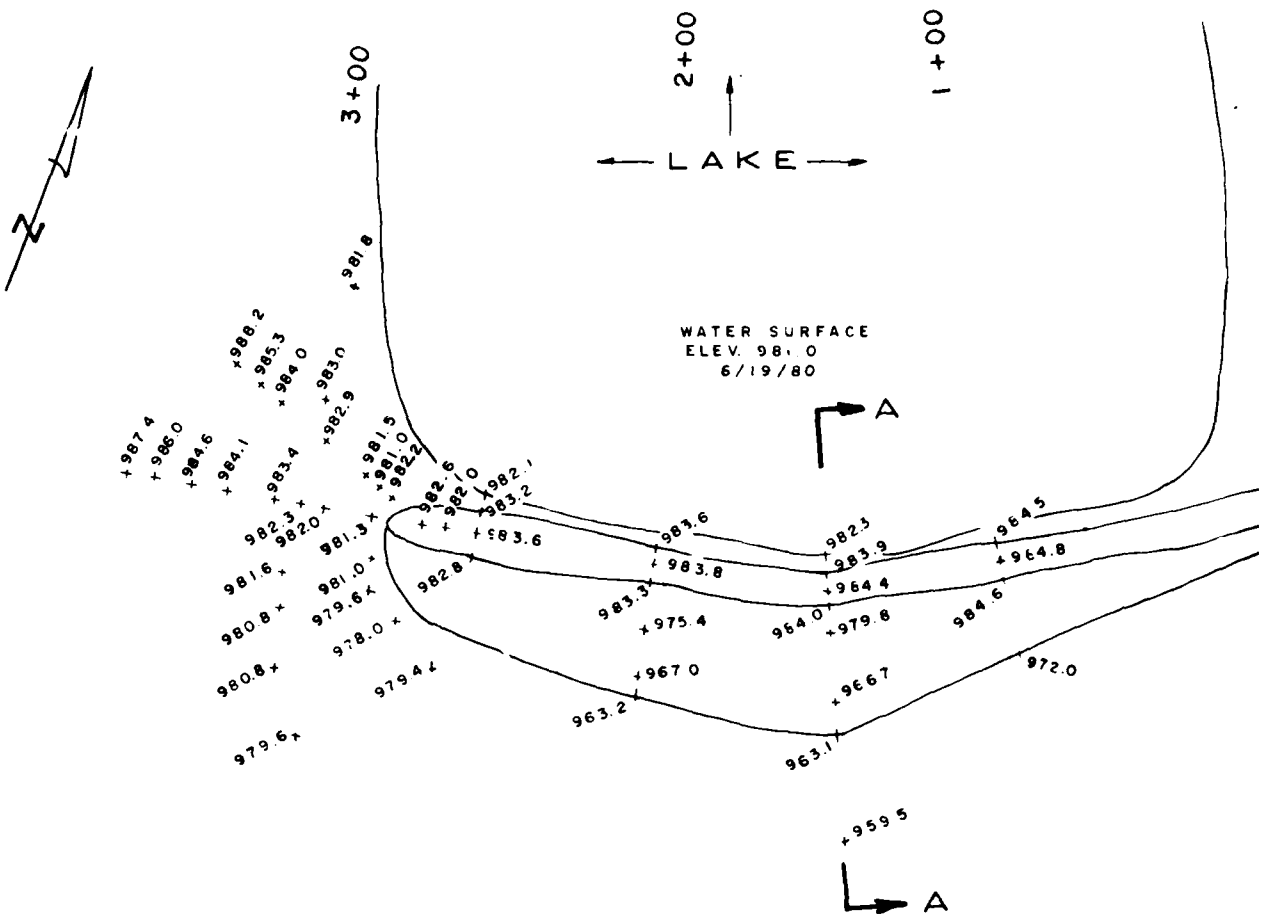
VICINITY MAP

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Merrill Lake Dam
Ozark County, Missouri
Mo. I.D. No. 30352

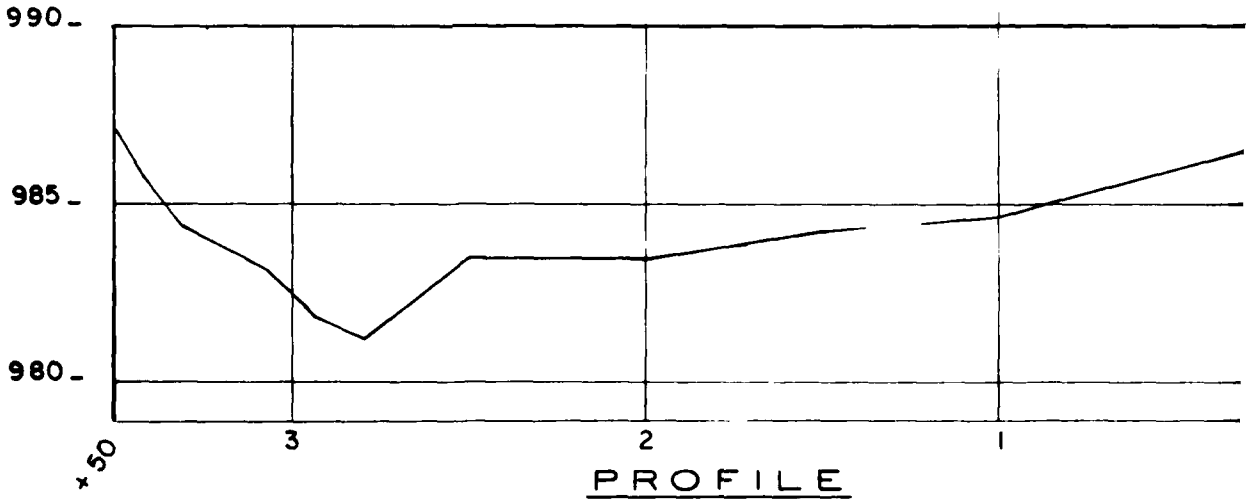
Sheet 2, Appendix A



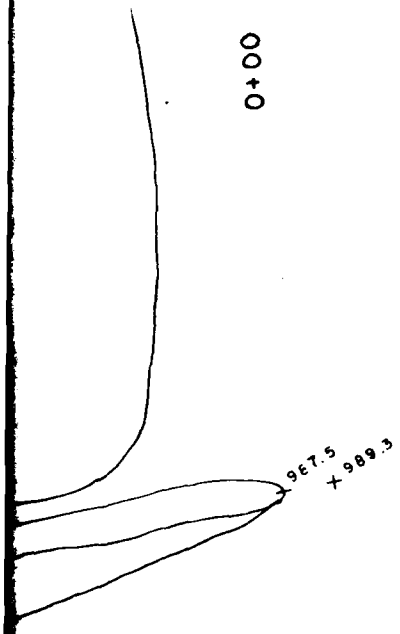
PLAN VIEW

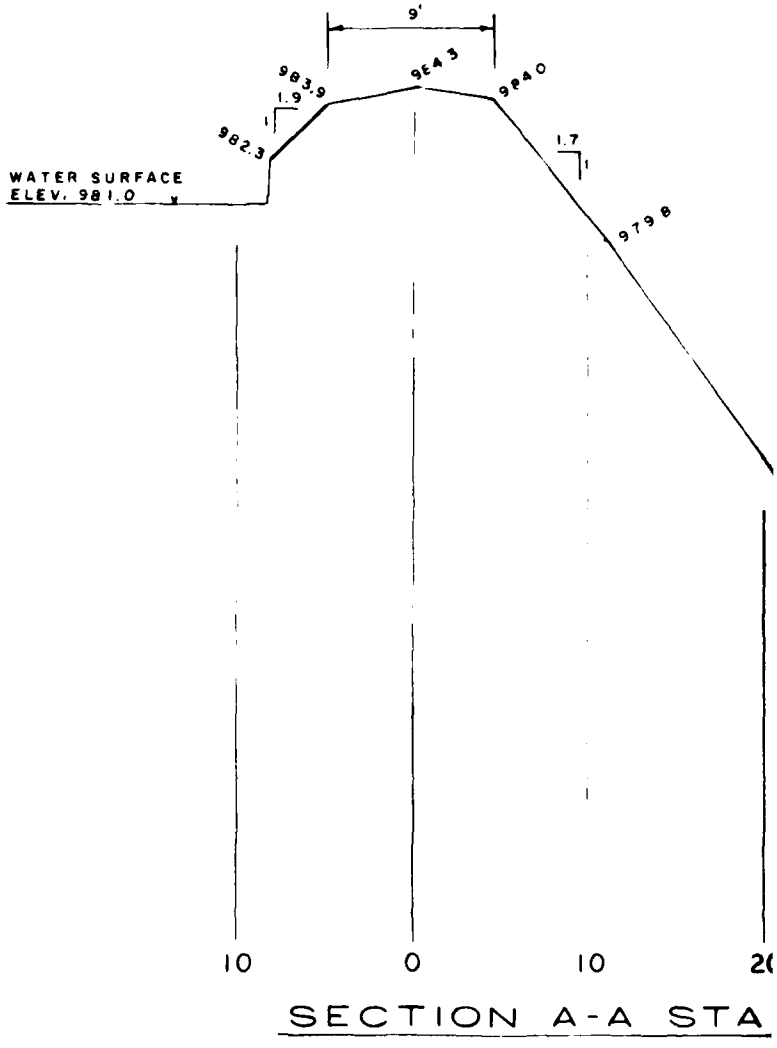
SCALE 1" = 50'

BENCHMARK
NORTH HEADWALL 48" CONCRETE PIPE
U.S. HIGHWAY 160, 800 FEET SOUTHWEST
OF DAM. ELEV. 934.02 M.S.L.

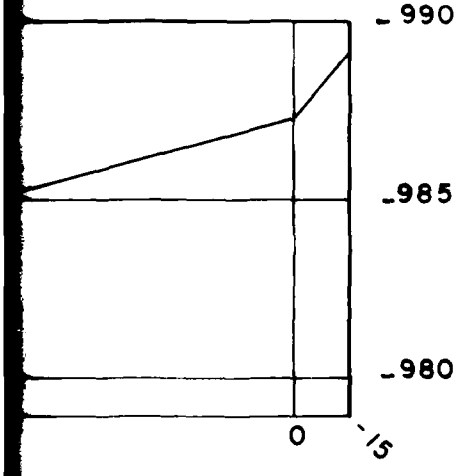


PROFILE





SECTION A-A STA



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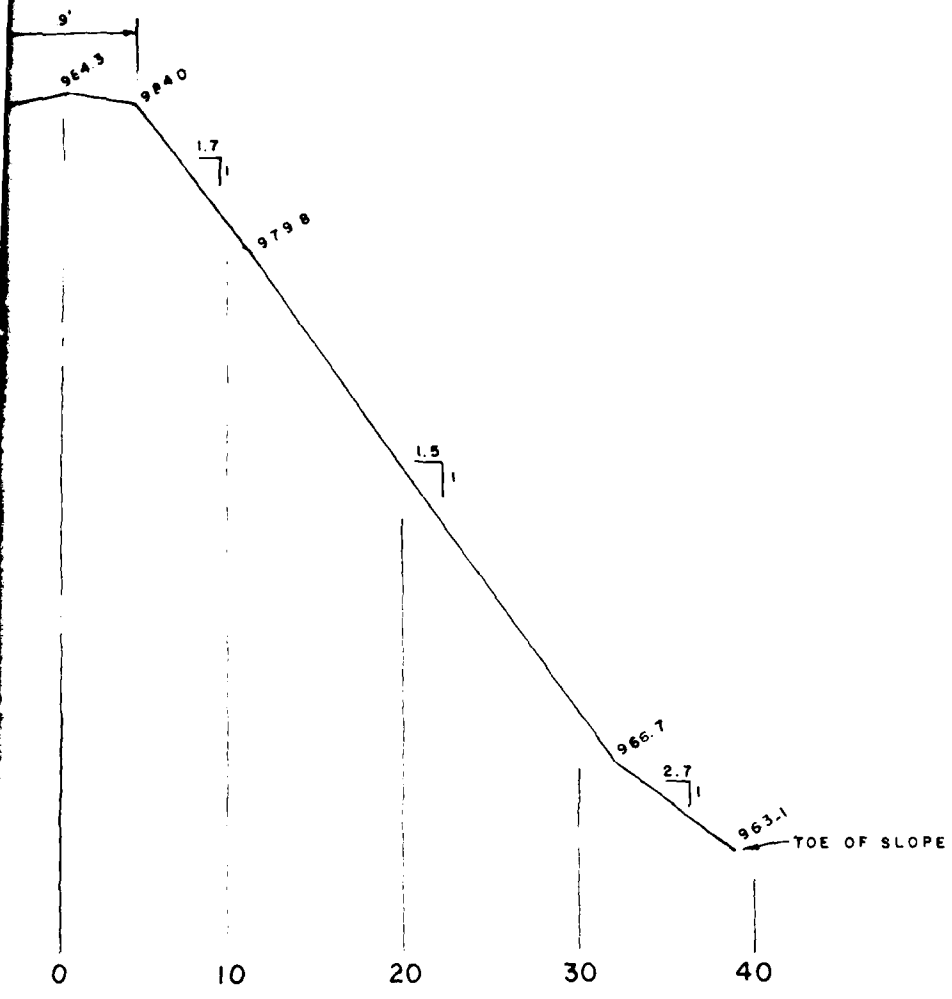


CTION A-A STA 1+50

SHEET 3 APPENDIX A

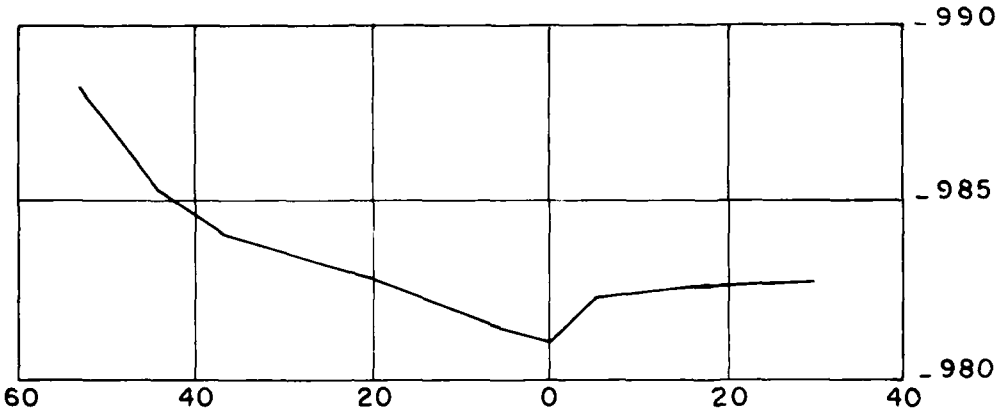
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

MERRILL LAKE DAM

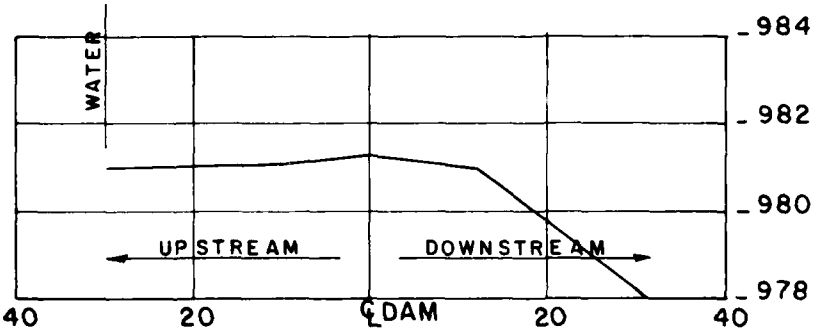
MO. No 30352

PLAN & PROFILE

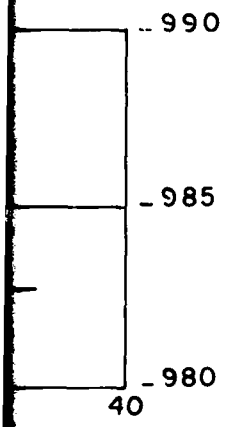
OZARK COUNTY, MO.

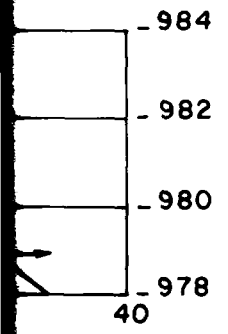


SPILLWAY SECTION



SPILLWAY PROFILE





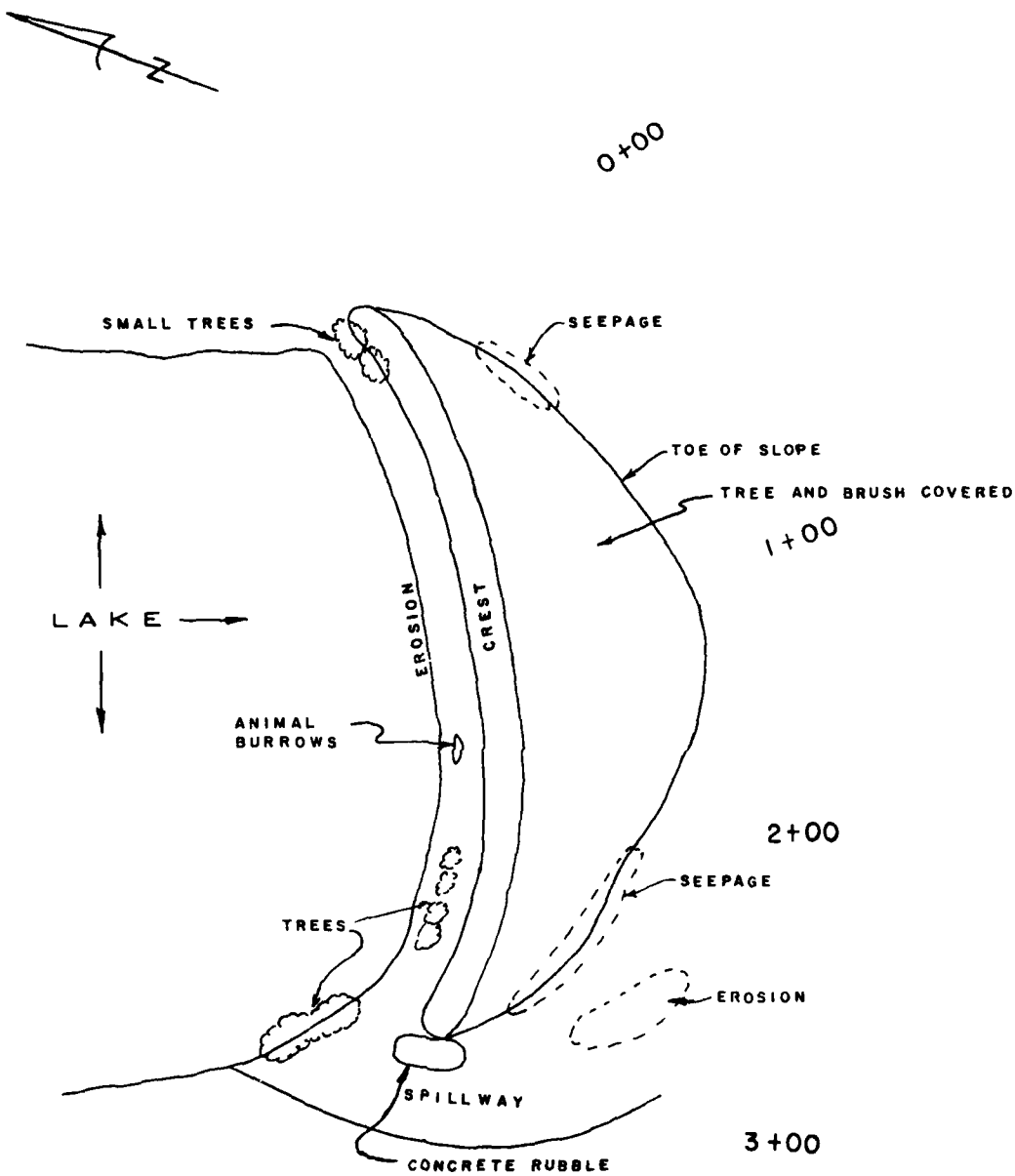
SHEET 3A APPENDIX A

ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

MERRILL LAKE DAM

MO. No. 30352

SPILLWAY
SECTION & PROFILE
OZARK COUNTY, MO.



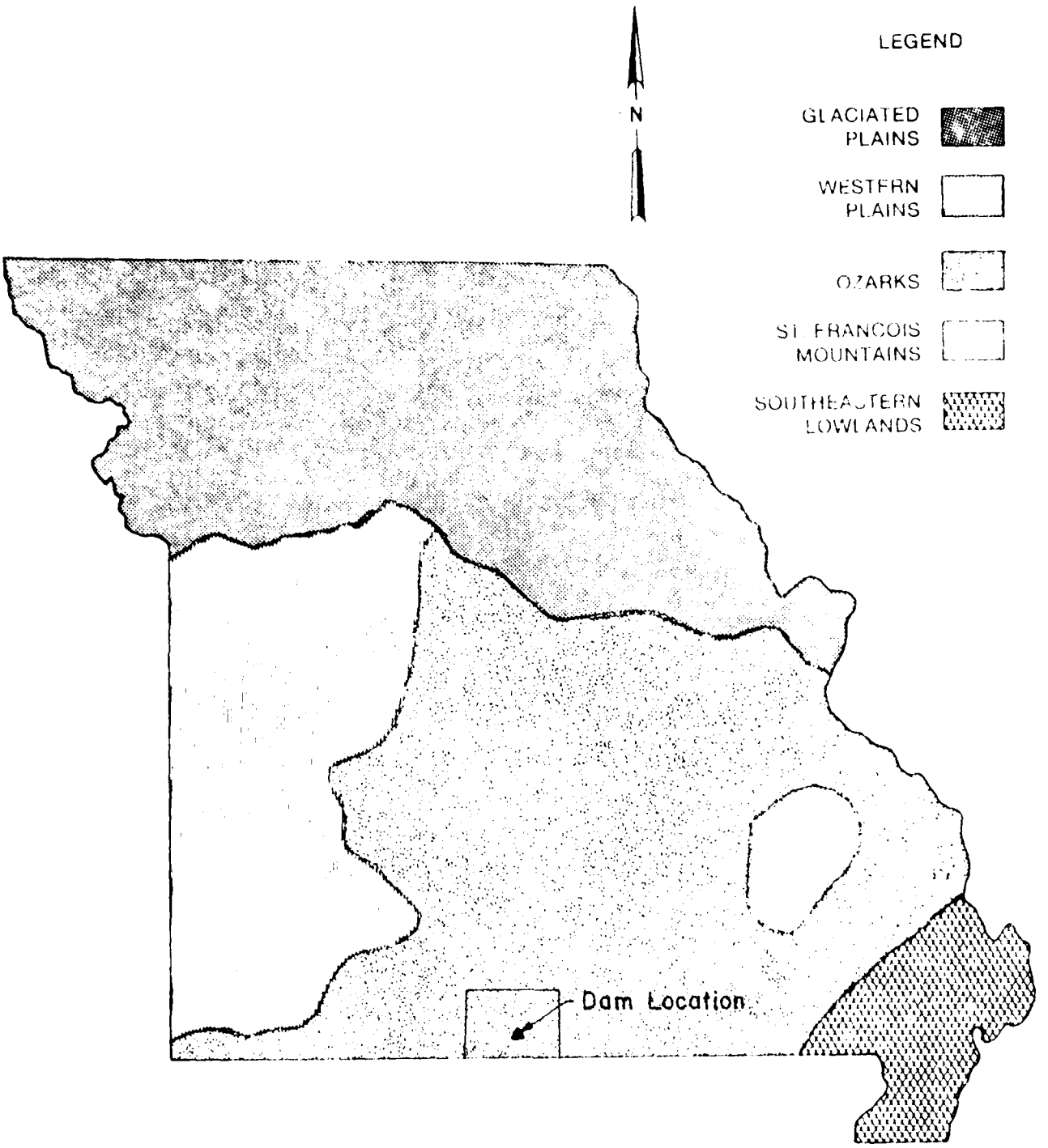
PLAN SKETCH OF DAM

MERRILL LAKE DAM

MO. No. 30352

APPENDIX B

Geology and Soils



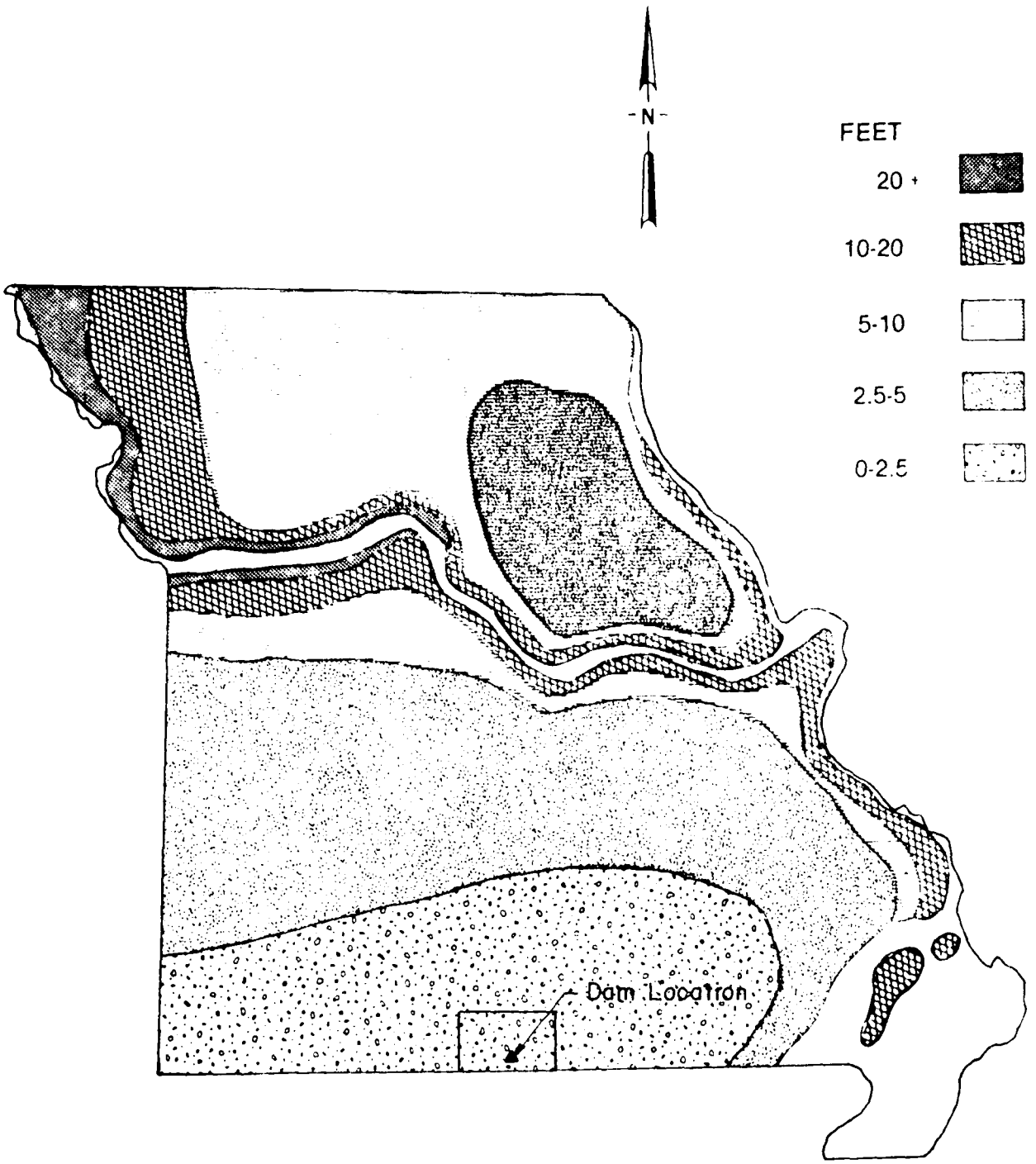
MAJOR GEOLOGIC REGIONS OF MISSOURI

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Merrill Lake Dam
Ozark County, Missouri
Mo. I.D. No. 30352

SHEET 1, APPENDIX B



THICKNESS OF LOESSIAL DEPOSITS

HANSON ENGINEERS

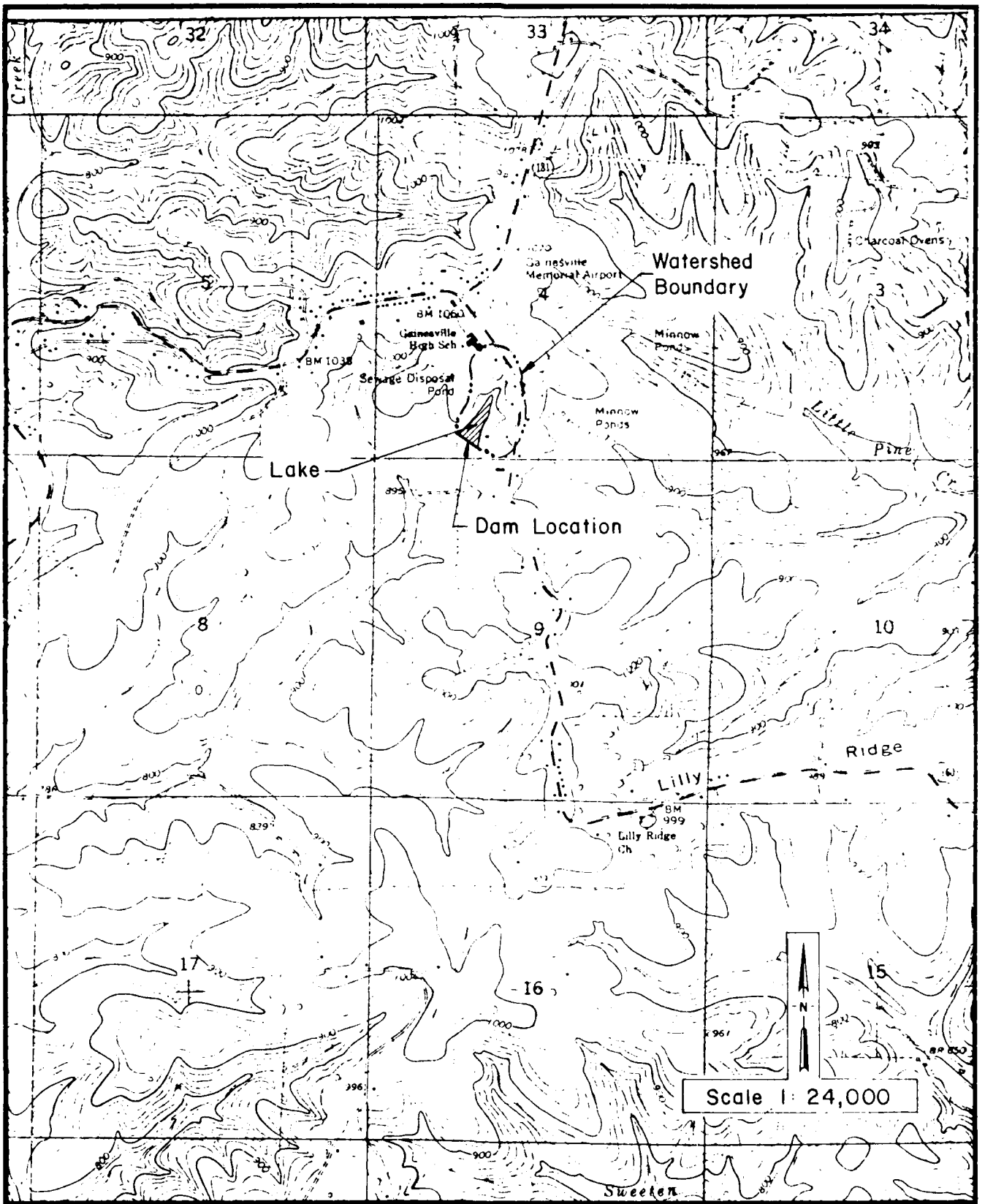
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Merrill Lake Dam
Ozark County, Missouri
Mo. I.D. No. 30352

SHEET 2, APPENDIX B

APPENDIX C

Overtopping Analysis


Watershed Boundary
Lake
Dam Location
Scale 1: 24,000
N
Merrill Lake Dam
Ozark County, Missouri
Mo. I.D. No. 30352
Sheet 1, Appendix C
LAKE AND WATERSHED MAP
HANSON ENGINEERS
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). Also, the 1 percent chance probability flood was routed through the reservoir and spillway. Springfield rainfall distribution (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corps of Engineers, was used in this case.

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The parameters for the unit hydrograph are shown in Table 1 (Sheet 3, Appendix C).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2 (Sheet 4, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method. The hydraulic capacity of the spillway was used as an outlet control in the routing. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 4, Appendix C.)

The rating curve for the spillways (see Table 4, Sheet 5, Appendix C) was determined assuming critical flow condition at the control section.

The flow over the crest of the dam during overtopping was determined using the non-level dam option ($L and $V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 6, Appendix C).

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 7, 8 and 9 of Appendix C.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.052 sq miles
Length of Watercourse (L)	0.15 miles
Difference in elevation (H)	68 ft
Time of concentration (Tc)	0.06 hrs
Lag Time (Lg)	0.04 hrs
Time to peak (Tp)	0.08 hrs
Peak Discharge (Qp)	315 cfs
Duration (D)	5 min.

Time (Min.)(*)	Discharge (cfs)(*)
0	0
5	299
10	84
15	16
20	3
25	0

(*) From the computer output

FORMULA USED:

$$Tc = \left(\frac{11.9\ L^3}{H} \right)^{0.385}$$ From California Culverts Practice, California Highways and Public Works, September, 1942.

$$Lg = 0.6\ Tc$$

$$Tp = \frac{D}{2} + Lg$$

$$Qp = \frac{484\ A.Q}{Tp}$$ Q = Excess Runoff = 1 inch

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	24	36.14	33.44	2.70
1% Prob. Flood	24	8.00	4.03	3.97

Additional Data:

1) Soil Conservation Service Soil Group B
2) Soil Conservation Service Runoff Curve CN = 78 (AMC III) for the PMF
3) Soil Conservation Service Runoff Curve CN = 60 (AMC II) for the 1 percent chance flood
4) Percentage of Drainage Basin Impervious 15 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

Elevation (feet, MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
958.4	0	0	-
*981.4	3.7	42	0
**983.6	4.4	52	210
985.0	4.8	58	640
987.0	5.4	68	-
1,000.0	9.2	-	-

*Principal spillway crest elevation

**Top of dam elevation

The above relationships were developed using data from the USGS Gainesville, MO 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAYS RATING CURVE

Reservoir Elevation (MSL)	Principal Spillway (cfs)
981.4	0
982.2	20
983.0	107
*983.6	210
984.2	360
984.7	560
985.0	640
985.5	960

*Top of dam elevation

METHOD USED: Assuming critical flow condition at the control section

FORMULA: $\frac{Q^2}{g} = \frac{A^3}{T}$

Q = Discharge in cubic feet per second
A = Cross sectional area in square feet
T = Water surface width in feet
g = Acceleration of gravity in ft/sec^2

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft, MSL)	Total Storage (acre-ft)	Peak Outflow (cfs)	Depth (ft.) Over Top of Dam
-	0	*981.4	42	0	-
0.10	106	982.2	45	19	-
0.15	159	982.5	47	48	-
0.20	212	982.7	48	77	-
0.25	264	982.9	49	100	-
0.30	317	983.1	50	126	-
0.40	423	983.4	51	182	-
0.45	476	**983.6	52	210	0
0.50	529	983.7	53	245	0.1
0.75	793	984.3	55	510	0.7
1.00	1,058	984.7	57	788	1.1

The percentage of the PMF that will reach the top of the dam is 45 percent.

* Principal spillway crest elevation
**Top of dam elevation

```
A       OVERTOPPING ANALYSIS FOR MERRIL LAKE DAM ( # 10 )
A       STATE ID NO. 30352  COUNTY NAME : OZARK
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 80S3001
B    300                5
B1     5
J      1        9        1
J1   .10      .15      .20      .25      .30      .40      .50      .75     1.0
K      0        1                                  3        1
K1       INFLOW HYDROGRAPH COMPUTATION **
M      1        2   0.052            0.052        1                         1
P      0     27.8      102      120      130
T                                                          -1      -78             0.15
W2  0.06     0.04
X      0     -.1        2
K      1        2                           0        4        1
K1       RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                    1        1
Y1     1                                                  42       -1
Y4 981.4    982.2    983.0    983.6    984.2    984.7    985.5
Y5     0       20      107      210      360      560      960
$S     0       42       52       58       68
$E 958.4    981.4    983.6    985.0    987.0
$$ 981.4
$D 983.6
$L     0       50      100      150      200      250
$V 983.6    983.8    984.4    984.8    986.2    987.5
K     99
```

PMF RATIOS
INPUT DATA

Sheet 7, Appendix C

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.75	1.00
HYDROGRAPH AT	1	0.05	1	106.	159.	212.	264.	317.	423.	529.	793.	1058.
	(	0.13)	(	3.00)(	4.49)(	5.99)(	7.49)(	8.99)(	11.98)(	14.98)(	22.46)(	29.95)
ROUTED TO	2	0.05	1	19.	48.	77.	100.	126.	182.	245.	510.	788.
	(	0.13)	(	0.54)(	1.37)(	2.18)(	2.83)(	3.58)(	5.15)(	6.94)(	14.45)(	22.30)

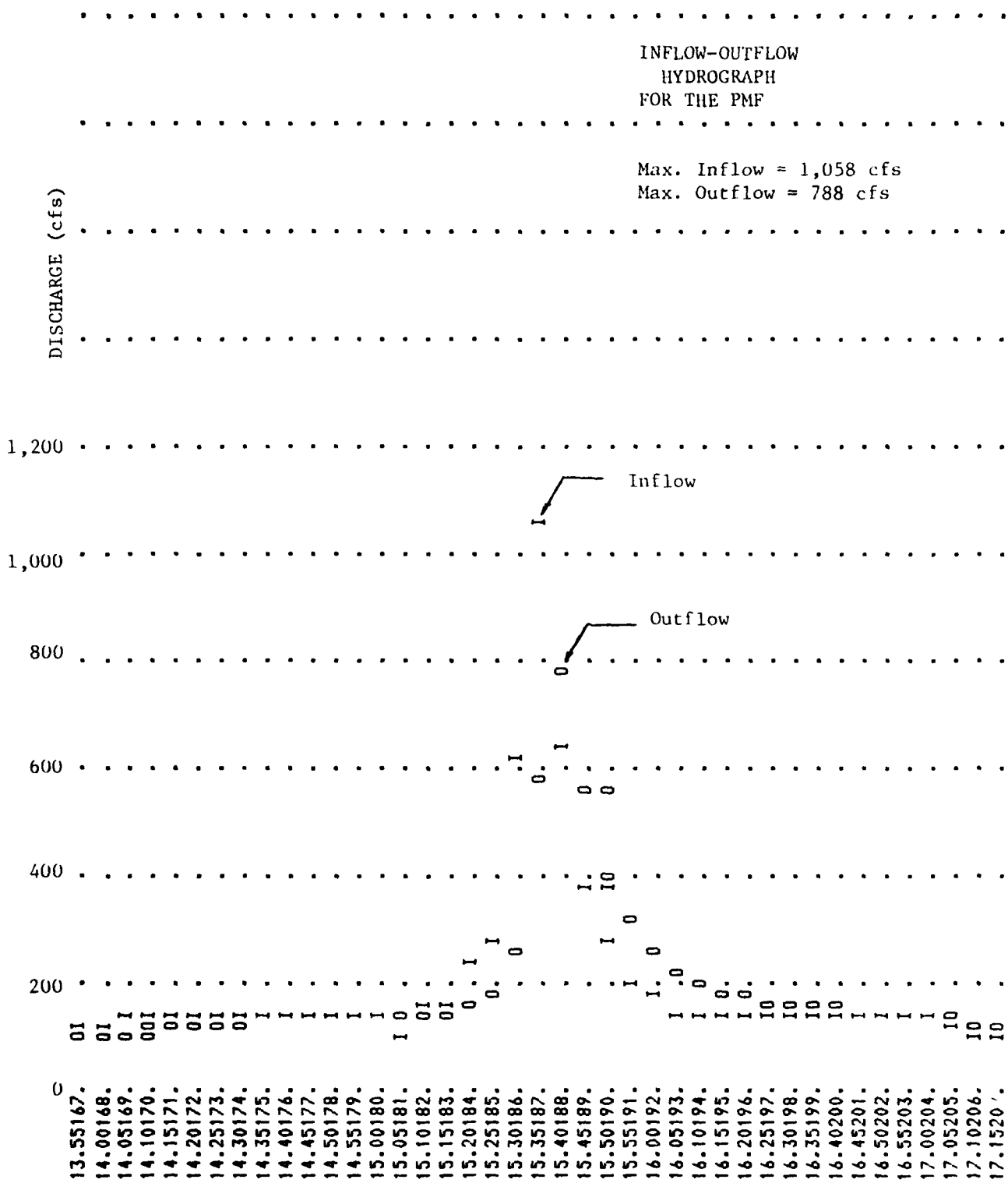
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	981.40	981.40	983.60
STORAGE	42.	42.	52.
OUTFLOW	0.	0.	210.

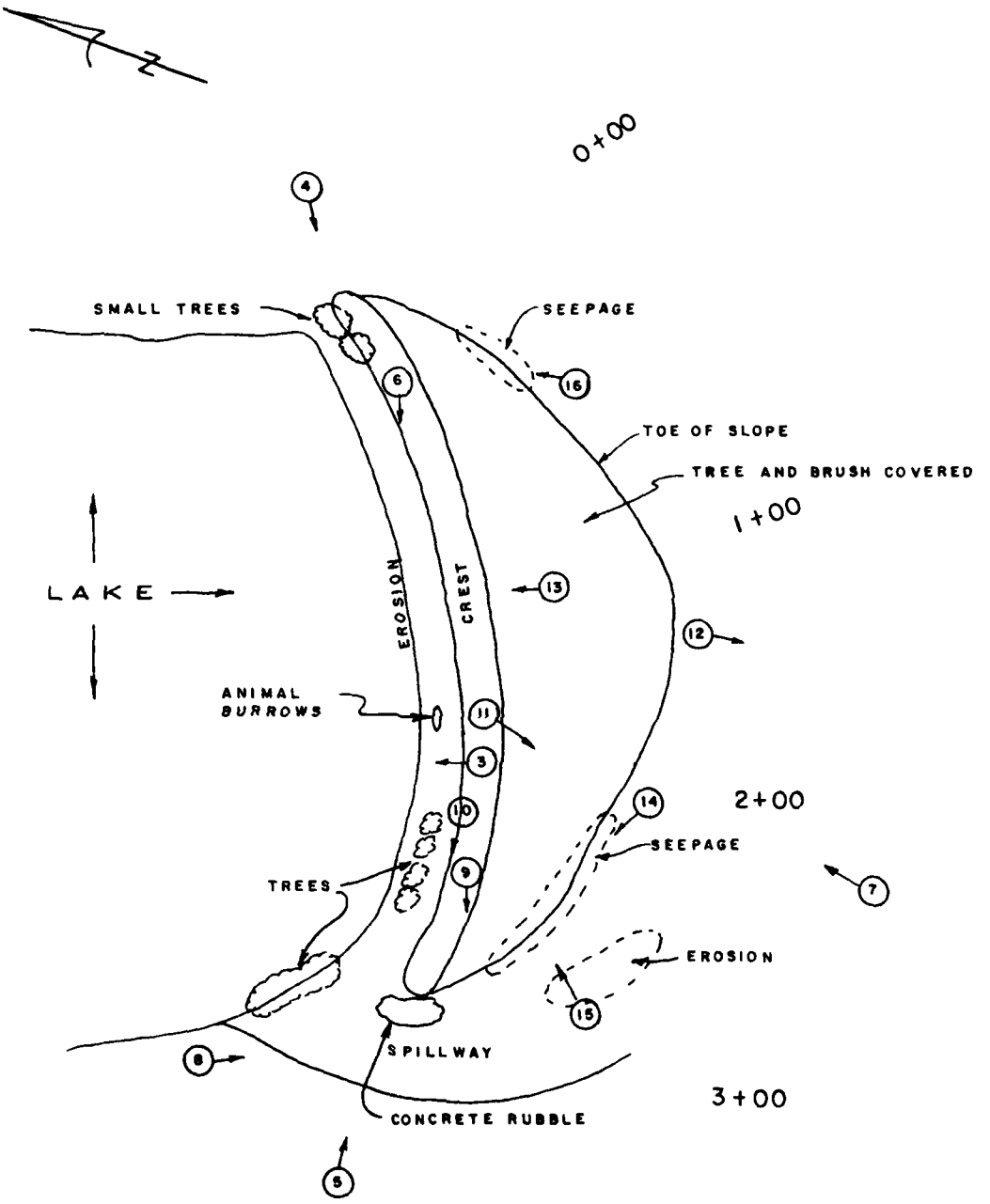
PMF RATIOS
OUTPUT DATA

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.10	982.17	0.00	45.	19.	0.00	15.92	0.00
0.15	982.46	0.00	47.	48.	0.00	15.83	0.00
0.20	982.72	0.00	48.	77.	0.00	15.75	0.00
0.25	982.93	0.00	49.	100.	0.00	15.75	0.00
0.30	983.11	0.00	50.	126.	0.00	15.75	0.00
0.40	983.44	0.00	51.	182.	0.00	15.75	0.00
0.50	983.73	0.13	53.	245.	0.25	15.75	0.00
0.75	984.33	0.73	55.	510.	0.50	15.67	0.00
1.00	984.69	1.09	57.	788.	0.67	15.67	0.00


INFLOW-OUTFLOW
HYDROGRAPH
FOR THE PMF
Max. Inflow = 1,058 cfs
Max. Outflow = 788 cfs
DISCHARGE (cfs)
1,200
1,000
800
600
400
200
0
Inflow
Outflow
TIME (hrs)

APPENDIX D

Photographs



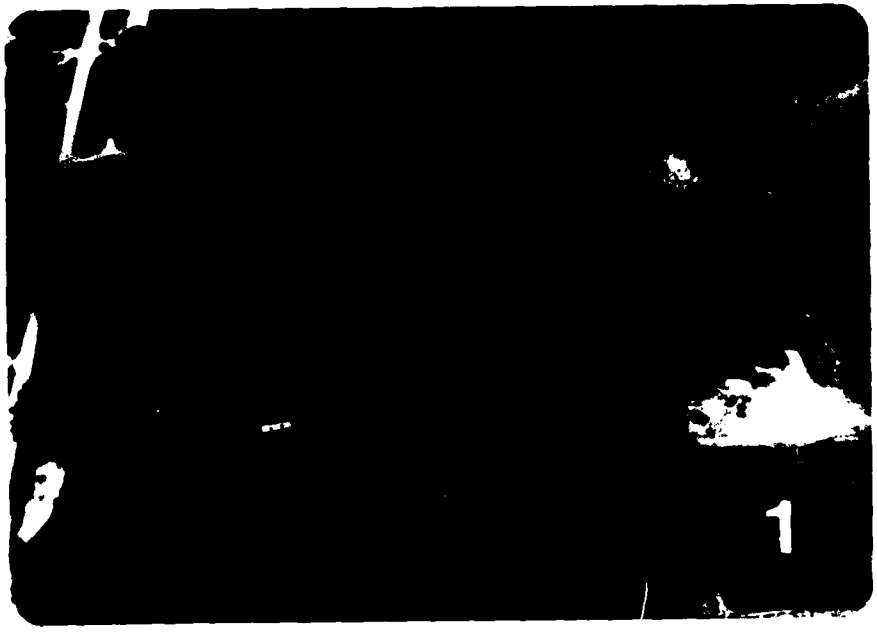
PHOTOGRAPH INDEX

MERRILL LAKE DAM

MO. No. 30352

LIST OF PHOTOGRAPHS

PHOTO NO.	DESCRIPTION
1	Aerial View of Lake and Dam
2	Aerial View of Lake and Dam
3	View of Reservoir and Lake (Looking North)
4	Crest of Embankment (Looking West)
5	Crest of Embankment and Spillway Channel (Looking East)
6	Upstream Face of Dam (Looking West)
7	Downstream Face of Dam (Looking Northeast)
8	Spillway Channel at Centerline of Dam (Looking South)
9	Spillway Channel at Centerline of Dam (Looking West)
10	Spillway Inlet Channel (Looking West)
11	Downstream Channel and Highway Fill (Looking Southwest)
12	Downstream Channel (Looking South)
13	Closeup View of Tree Stump on Downstream Slope (Looking North)
14	Seepage Area at Spillway-Embankment Contact (Looking North)
15	Downstream Face of Dam (Looking East)
16	Wet Area at Embankment-Abutment Contact (Looking North)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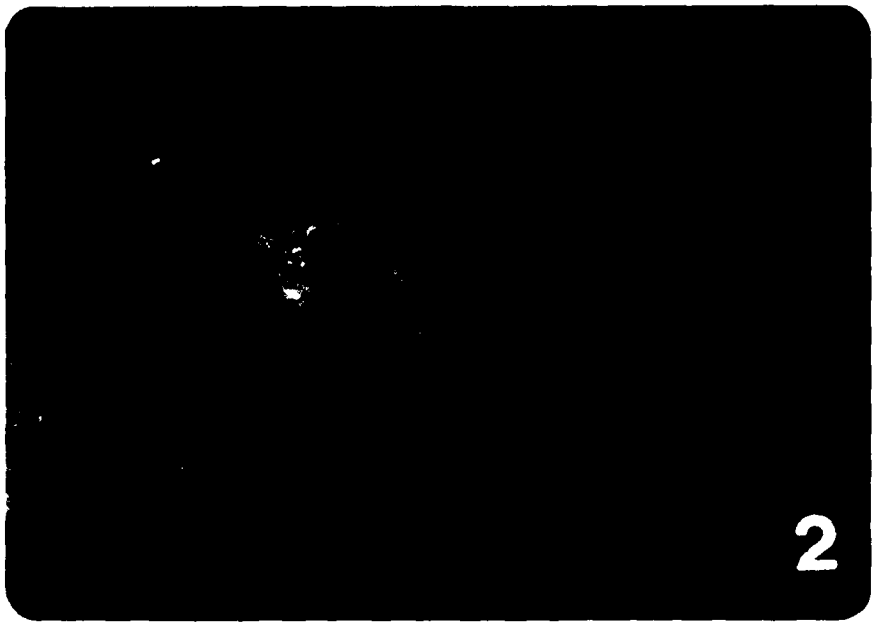
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